The effects of price and non-price policies on cigarette consumption in South Africa

Ernest Ngeh Tingum, Alfred Kechia Mukong and Noreen Mdege

ERSA working paper 799

October 2019

The effects of price and non-price policies on cigarette consumption in South Africa

Ernest Ngeh Tingum*, Alfred Kechia Mukong†and Noreen Mdege‡

October 1, 2019

Abstract

The health consequences of smoking are serious and have been frequently detailed. A reduction in tobacco-related mortality hinges upon the ability to reduce tobacco usage. There is overwhelming evidence that higher cigarette prices reduce cigarettes demand, but little is known about the combined effect of price and non-price policies. This paper extends the analysis of price elasticities by estimating the effect of changes in price and non-price legislations in South Africa. Annual time-series data from 1961 to 2016 are used, with a policy index constructed to capture the instances of non-price tobacco legislation. The combined impact is estimated using a vector error correction model and a two-stage least squares (2SLS) model. The long-run own-price elasticities lie between -0.55 and -0.72, while the income elasticities lie between 0.39 and 0.49. The coefficients of the changing tobacco policies and changing market structure show that they contribute to a modest reduction in cigarette consumption. The short-run deviations from the steady state are presented using the error correction term. Cigarette demand is responsive to prices and non-pricing policies but failure to control for non-pricing policies overstates the price effect. This suggests that both prices and non-pricing legislation are effective in reducing cigarette consumption.

1 INTRODUCTION

Smoking is known to have serious and well-documented health consequences. As a result of the elevated risk of smoking-related diseases, someone who took up smoking early in life can be expected to die about 6 years earlier than a comparable non-smoker.[1] According to Statistics South Africa (2017), tobacco

*Department of Economics, National University of Lesotho. Research Unit on the Economics of Excisable Products (REEP), School of Economics, University of Cape Town, South Africa.. Corresponding author: ngehernest@gmail.com

†Research Unit on the Economics of Excisable Products (REEP), School of Economics, University of Cape Town, South Africa. Department of Economics, University of Namibia, Windhoek, Namibia.

‡Department of Health Sciences, University of York, United Kingdom.

use accounts for over 170,000[1] deaths annually, an increase from 44,000.[2] The ability to reduce the number of tobacco-related deaths, therefore, depends upon the ability to reduce tobacco consumption. Tobacco taxes and a number of tobacco-control policies have been implemented around the world with the objective of increasing the cost of purchasing tobacco products, thereby reducing consumption.

Many studies on the relationship between cigarette prices and cigarette consumption have shown that increased cigarette prices are one of most effective tobacco-control strategies.[2] On the other hand, relatively little attention has been given to the effect of non-pricing tobacco legislation. The literature on the elasticity of demand for cigarette can be classified into two strands. The first strand, quite sizable, completely ignores the role of non-pricing policies when estimating the price elasticity of demand for cigarettes.[2] Another strand of literature controls for the effect of other tobacco legislations.[3] We argue in this paper for the need for a simultaneous evaluation of pricing and non-pricing tobacco-control policies in order to reduce the bias associated with the price elasticity of demand for cigarettes. Without this, this price elasticity will be overstated.

The few studies that have considered the role of non-pricing policies simply introduced a dummy variable into the cigarette demand function.[4–6] The introduction of a dummy variable may not adequately address this problem, especially for economies that frequently amend their tobacco control legislation. Joossens and Raw provided weights for the different tobacco control policies which can be used for constructing a tobacco-control policy index.[7,8] This measure is particularly important when estimating the effect of non-pricing laws for a country that has systematically amended its tobacco-control legislation. To date, very few published studies have used a comprehensive measure of other pieces of legislation when estimating the price elasticity of demand for cigarettes. The purpose of this paper is to address this evidence gap in the context of South Africa, a developing country that has passed a number of tobacco-control laws in order to significantly reduce the level of adult cigarette consumption.

Compared to many low- and middle-income countries (LMICs), South Africa is noted for the use of heavy excise taxes and other tobacco-control policies aimed at reducing cigarette consumption per adult by almost half within 15 years.[9,10] For example, adult smoking prevalence decreased from a third of the adult population to about a fifth between 1994 and 2012.[11] While this decline is attributed mainly to the increase in excise taxes, the influence of numerous non-pricing policies, including banning tobacco advertising and sponsorship, as well as banning smoking in public and work places, cannot be ignored. In addition, smoking prevalence is still significantly high among adults.[12] Recent evidence from individual-level panel data indicates that the conditional price elasticity of demand for cigarettes in South Africa decreased from -0.305 to -0.303 after controlling for non-pricing policies.[12] However, this study, like previous studies

[1] Stats SA (Statistics South Africa). 2017. "Mortality and Causes of Death from Death Notification 2015." Statistical Release P0309.3, Stats SA, Pretoria.

[2] Cancer Society of South Africa, 2013. Fact Sheet on Tobacco Products.

in South Africa.[5,6] used a dummy to capture the effect of non-pricing policies. The current study differs from these studies in that it considers a more comprehensive measure of non-pricing policies.

In South Africa, tobacco taxes constituted 30% of the price of tobacco products in 1992 and are regarded as the intervention that has contributed most to the significant decline in tobacco consumption. Since 1994, South Africa has consistently and aggressively increased the excise tax on cigarettes to meet and maintain the total tax burden (inclusive of value added tax) of 50% of the average retail price.[10] This target was achieved in 1997, and revised upward to 52% in 2004. The high excise taxes increased real cigarette prices by 115% between 1993 and 2003.[5] and by 190% between 2004 to 2012.[10] As shown in Figure 1, the decline in cigarette consumption and smoking prevalence from about a third to less than a fifth between 1994 and 2012 is partly attributed to the substantial increase in real cigarette prices.[11,13] In addition to excise taxes, South Africa has implemented a number of comprehensive tobacco-control policies in the Tobacco Product Control Act (TPCA) of 1993, including; health warnings on cigarette packs and advertising material. This legislation was amended in 1999, 2007 and 2008 to include a ban on tobacco advertising, sponsorship, smoking in public and in workplaces and the sale of tobacco to minors.[5,10]

A number of empirical studies have analyzed the relationship between real cigarette prices and the demand for cigarettes in South Africa, without taking into account the combined effects of non-pricing tobacco control legislation.[6,11,14–19] This is largely because the implementation of the non-price policies occurs in different years across the decades. The present study will address the evidence gap by estimating the combined impact on consumption of price changes, changes in legislation, and changing market structure. We show that ignoring anti-smoking legislation overstates the price effects but understates the income effects both in the long term and the short term. Our results contribute to the literature on the effect of tobacco-control policies on cigarette consumption. A better understanding of this relationship can help inform the discussion on appropriate policies that will further reduce tobacco use. The study employs the econometric techniques of the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) unit root tests, the Johansen cointegration test, the vector error orrection model (VECM) and a two stage least square (2SLS) estimation in the analysis.

2 METHODOLOGY

2.1 The Theoretical Model

This paper uses the demand model to estimate the effect of price and non-price tobacco control legislation on cigarette consumption in South Africa from 1961 to 2016. There is a well-established relationship between price and income and cigarette consumption. According to[15,20,21], the demand function for cigarettes is expressed as follows:

$$Q_t = f(P_t, Y_t, A_t, D_t) \quad (1)$$

Where Q_t is the per capita cigarette consumption in period t, P_t is the real price of cigarettes adjusted for inflation (2016=100 in this case), Y_t is the real per capita Gross Domestic Product (GDP), A_t is the index of the non-price tobacco control policies, and D_t is the dummy variable for the change in market structure that occurred in 2010. The short-run and long-run analyses in this study are based on the demand function given above.

2.2 Data sources

The analysis uses annual time-series data for the period 1961 to 2016. The data are extracted from Statistics South Africa (StatSA) and South African Reserve Bank (SARB) reports. The dependent variable is annual adult per-capita cigarette consumption. This is calculated by dividing the aggregate consumption by the size of the adult population (15 years and above). The relationship between aggregate cigarette consumption and real cigarette prices in South Africa is presented in Figure 1. This figure shows substantial increases in the real price of cigarettes since 1994 as a result of the implementation of an aggressive excise tax policy. In contrast to the period before 1994, when real prices were falling, the average real price per pack increased by 190% between 1994 and 2012 and has remain almost constant afterwards. Cigarette consumption increased during the period 1961-1993, started falling moderately, then its fall accelerated from 1995 through 2000. The decrease can be attributed to the policies, adopted by the democratically elected government in 1994, that reduced smoking prevalence. The decrease in smoking prevalence is also attributed to the excise tax increment of 25% in 1994, 25% in 1995 and 18% in 1996.[22] In 1997, the government announced a 52% increase in the excise tax on cigarettes, which was expected to bring the total tax burden to 50% of the average retail selling price.[5, 10] The total tax burden was revised to 52% of the average selling price in 2004.[23]

The independent variables include real prices (adjusted for inflation by dividing the nominal prices by the consumer price index, using 2016 as the base year), real per capita GDP, a policy index, and a dummy for the changing market structure. Real per capita GDP is measured as the ratio between the real GDP (published by SARB) and the adult population. To measure the importance of the tobacco-control policies for reducing tobacco consumption, a tobacco policy index is constructed for the period 1961-2016. The index is constructed for policies other than cigarette taxes. Cigarette taxes are embedded in cigarettes prices and the individual effect of prices on consumption can be netted out in the demand model. The process of constructing the policy index follows a new tobacco-control scale (TCS) approach that measures the different non-pricing policies of countries.[7, 8] The TCS, which quantifies the implementation of tobacco control policies at country level, is based on six policies described by the World Bank.[24]

The six policies are: (1) price increases through higher taxes on cigarettes

and other tobacco products; (2) bans/restrictions on smoking in public and work places; (3) better consumer information, including public information campaigns, media coverage, and publicizing research findings; (4) comprehensive bans on the advertising and promotion of all tobacco products, logos and brand names; (5) large, direct health warning labels on cigarette packages and other tobacco products; and (6) treatment to help dependent smokers quit, including increased access to medications. In South Africa, the introduction of these policies started in the 1990s, allowing us to score them into a policy index using the TCS.[8] For the current study only five policies are scored in the index, which excludes cigarette taxes (Table 1). The complete table of the policies is in appendix 7 (see supplementary material).

A dummy variable is used to capture the change in market structure that occurred in 2010. The variable is coded 0 for periods before 2010 and 1 otherwise. Before 2010, British American Tobacco's (BAT) main competitors were multinationals and other subsidiaries such as Philip Morris South Africa, Japan Tobacco International and Imperial Tobacco, but BAT was the unchallenged price leader. From 2010, there was a substantial change in the cigarette market structure in South Africa. The high profits earned by BAT and other multinationals attracted many small cigarette manufacturers and distributors, such as Gold Leaf Tobacco Company, Folha Manufacturers, and Savanna Tobacco Company SA among others, who undermined the established firms by selling at lower prices. During this period, there was also a substantial increase in illicit trade.[11, 25]

The stationarity of the time series was tested using the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) unit root tests.[26, 27] The data were converted into logarithms in order to reduce their variability. Based on the ADF and PP tests, the hypothesis that the log of per capita consumption, the log of real prices and the log of real per capita GDP contain a unit root cannot be rejected at a 5% significance level. However, we fail to reject the assumption of stationarity after first differencing these variables. The critical values for the ADF and PP tests at first difference at 5% are -3.497 and -3.496 respectively. Compared to the test-statistic values, the variables are stationary at first differences (see Figures 3 and 4; Appendix 2), and thus, standard statistical inference is validated.[28] This suggests that a cointegration approach can be used to test for the existence of a long-run relationship between the variables.

2.3 Cointegration and long-run equilibrium estimations

Before estimating the co-integrating vector, the appropriate lag length to be used in the estimations of the cointegration test and in the vector error correction model (VECM) was determined using the vector auto-regression (VAR) test. The lag length is selected if the majority of the selection criteria favor a particular lag.[28] The appropriate lag length used in the cointegration test and VECM model is presented in Appendix 3. The results show that the majority of the selection criteria, such as Akaike's information criterion (AIC), the Hannan-Quinn Information Criteria (HQIC), and the Schwartz-Bayesian Infor-

mation Criteria (SBIC), select the optimum lag length of 1 (see Appendix 3 in Supplementary material).

Cointegration was then tested using the Trace and the Maximum Eigenvalue tests.[29] which use a maximum likelihood procedure that jointly estimates the number of cointegration vectors to determine the existence of a long-run relationship between the variables. The results, presented in Appendix 4, show that there is one cointegrating vector among the variables. This signifies the existence of a long-run relationship among the variables that can be combined with the short-run dynamics using a Vector Error Correction Model.[21,30]

The long-run equilibrium model uses a double-logarithmic demand equation which gives a straightforward interpretation to the coefficients (elasticities). A conventional econometric model for estimating the demand for cigarettes is specified as follows:

$$InQ_t = \alpha_0 + \alpha_1 InP_t + \alpha_2 InY_t + \alpha_3 A_t + \alpha_4 D_t + \mu_t \tag{2}$$

The variables Q_t, P_t, Y_t, A_t and D_t have already been defined earlier. α_i is the constant term where $i = 0, 1, 2, 3, 4$ and μ_t the random error term. The vector error correction model (VECM) used to determine the long run relationship is as specified in:.[31]

$$\begin{aligned} dLnQ_t &= \beta_0 + \beta_1 \sum_{i=1}^{j-1} dLnQ_{t-i} + \beta_2 \sum_{i=1}^{j-1} dLnP_{t-1} + \beta_3 \sum_{i=1}^{j-1} dLnY_{t-1} \\ &\quad + \beta_4 A_t + \beta_5 D_t + \lambda_i ECT_{t-1} + \mu_t \end{aligned} \tag{3}$$

Where $j-1$ is the lag length which is reduced by 1 since 1 lag is lost from differencing a VAR, d is the difference operator, β_i represents the short-run dynamic coefficients of the model's adjustment to long-run equilibrium, λ_i is the speed of the adjustment parameter and ECT_{t-1} is the error correction term which is the lagged value of the residuals obtained from the cointegrating regression of the dependent variable on the regressors. μ_t is the stochastic error.

One concern that is often raised in the context of the estimation-of-demand equation is that cigarette prices are endogenous owing to the simultaneity of cigarette consumption and prices (Deaton, 1997). The market clearance price could be determined by the interaction between the demand and supply sides of the market and the estimates of price elasticity biased if the problem of endogeneity is ignored.[4,32] This study employs a two-stage least squares (2SLS) approach to address the potential endogeneity of cigarette prices. Excise taxes and lag of prices are the commonly used instruments for determining real cigarette prices.[33] The justification is that these two instruments serve the same purpose as price variable in affecting consumption behaviour, but are entirely independent of the individual's smoking decision.[32] Moreover, the effectiveness of excise tax increases as a tool for reducing tobacco consumption depends largely on how the tax increases impact the retail price.[11,33]

3 RESULTS AND DISCUSSION

The VECM was estimated at lag length of 1 with 1 cointegrating vector, and the results are summarized in Table 2. The demand equation for annual cigarette consumption obtained from the VECM and 2SLS estimations is reported in Tables 2. Table 3 presents the first stage estimates of the 2SLS method. Appendix 6 shows estimated results of the demand equation using specific dummies for the existing legislative acts in South Africa. The relevant legislation is the Tobacco Product Control Act, no 83 in 1993, that was amended in 1999, 2007 and 2008.

The VECM uses stationary data at first differences and includes the lagged residuals of the long-run relationship as an explanatory variable. Coefficients from ECM represent the relationship in the short run, and the coefficient of the lagged residuals measures the speed of convergence to the long-run equilibrium. The error correction term is the speed of adjustment in the direction of long-term equilibrium after any deviation from the steady state. The error correction terms in Table 2 have the correct sign and are significant. This indicates that per capita cigarette demand converges to steady state equilibrium at the speed of 15% in the restricted model (see column 1) and 26% in the unrestricted model (see column 2).

The estimated short-run dynamic coefficients of the real price and per capita income on per capita cigarette consumption are respectively -0.263 and 0.226 for the restricted model and -0.352 and 0.283 for the unrestricted model. The long-run price and income elasticities were estimated to be -0.722 and 0.394 for the restricted model and -0.548 and 0.487 for the unrestricted model. The results suggest that price increases are an effective anti-smoking policy. A 10% increase in cigarette prices reduces per capita cigarette consumption by 5% to 7% in the long run. The positive and significant effect of income on cigarette consumption indicates that an increase in the income of smokers will result in higher levels of cigarette consumption, but to a lesser degree than the reduction caused by price increases.

The Durbin-Wu-Hausman test of exogeneity of regressors is used to test for the orthogonality of the unobserved disturbances in the demand equation. The test statistics in Table 2 suggest that cigarette prices are endogenous. Estimates of the first stage regression suggest that taxes and the lag of prices are valid instruments for cigarette prices. The strength of the instruments is tested using the robust F statistics (greater than 10). This shows that the variables *tax* and *lagged prices* are strong predictors of cigarette prices. The 2SLS estimates show that a 10% increase in the price of cigarettes reduces cigarette consumption by 5.2% when cigarette excise taxes are used and 5.9% when the lag of prices is used. According to Chaloupka *et al.* (2000), the estimates of the price elasticity of demand for cigarettes in low-and-middle income countries are between -0.5 and -1.0 and between -0.25 and -0.5 for high-income countries. The present estimate is in this range and lies between -0.52 and -0.57. The effect of income is reduced to 0.12 after controlling for endogeneity but remains significant (see Table 2 for 2SLS estimates).

It should be noted that the impacts of price and income presented here

are lower than those of Boshoff,[6] estimated over the period from 1996 to 2000. The differences in estimated value are most probably due to the differences in datasets and methodologies employed. Boshoff's paper uses a quarterly dataset (which includes only wholesale cigarettes) obtained from a prominent South African manufacturer while the present study uses annual retail sales data to estimate elasticities. Boshoff employs the unrestricted vector auto-regression (VAR) which treats all variables as endogenous. This approach models each dependent variable as a function of its past values and the past values of other variables included in the model.

The policy index has a negative and statistically significant effect in the long run and for the 2SLS estimation. This suggests that introducing non-pricing tobacco-control legislation tobacco use will effectively and significantly reduce cigarette demand in the long run. This is because, in the long run, smokers become aware of the regulations as they are implemented and enforced. The dummy for the change in market structure is negative and significant in the long run. Even though the change in market structure in 2010 (from near monopoly to a more competitive market) led to lower prices being offered by new entrants in the market, the negative and significant coefficient indicates the percentage of the formal cigarette market (official cigarette consumption) that was lost to illicit trade post-2010.

The estimated results in Table 2 satisfy the VECM diagnostic tests, namely, absence of serial correlation (Lagrange Multiplier test), normality of errors (Jarque-Bera test) for the restricted model, and stability with 4 unit moduli. Stability of the VECM is confirmed using the graphs of the roots characteristics in Figure 2.

4 CONCLUSION

This paper provides the combined effect of price and non-price policies on cigarette consumption in South Africa, a country that has a track record of effective tobacco control policies, yet still experiences an increase in the burden of smoking-related disabilities. Cointegration techniques, vector error correction models (VECM), and data for the period 1961 to 2016 were used to investigate these relationships. The VECM post-estimation tests show that the model was stable, that there was no autocorrelation, and that the errors were normally distributed

The findings are in line with the theoretical expectations, that is, demand is a negative function of price and a positive function of income. The findings show that long-run cigarette price effects exceed short-run effects. The short-run price elasticity estimates range from -0.26 to -0.35, while the long-run estimates range from -0.55 to -0.72. This suggests that a 10% increase in cigarette price would lead to a 3% to 4% decrease in cigarette consumption in the short run and a 6% to 7% decrease in the long run. Thus, a given percentage increase in the price of cigarettes will lead to a less than proportionate decrease in cigarette consumption. The estimated coefficient of the policy index (-0.16) is highly

significant in the long run, which suggests that the implementation of non-price tobacco control policies in South Africa reduces total cigarette consumption. The coefficient of the changing of the market structure from near monopoly to a more competitive market is negative, indicating a reduction in official cigarette consumption.

The results of this study show that the implementation and enforcement of anti-smoking policies would potentially reduce cigarette smoking, consequently resulting in an improvement in public health. More than simply price increases is required to reduce cigarette consumption continuously in South Africa. As governments commit to raising cigarette taxes as a way of reducing cigarette consumption, other non-price legislation should not be ignored.

Conflicts of Interest: The authors declare no conflict of interest.

Funding: Funding for ENT and NM is acknowledged from the Tobacco Control Capacity Programme (grant MR/P027946/1) supported by UK Research and Innovation (UKRI) with funding from the Global Challenges Research Fund. Funding for AKM is from the International Development Research Centre (IDRC) (Project number: 108442-002) and the Carnegie foundation, New York.

Acknowledgement: We are grateful for the valuable comments and suggestions received from the anonymous reviewer(s) of the Economic Research Southern Africa (ERSA) working paper series. We are also grateful to Corne van Walbeek and colleagues at Research on the Economics of Excisable Products (REEP) for valuable comments and suggestions.

Authors' Contributions: ENT was involved in data analysis, writing and revising the manuscript. AKM in data analysis and reviewing the manuscript, NM in reviewing and editing. All authors read and approved the final draft.

References

[1] Cutler DM, Gruber J, Hartman RS, Landrum MB, Newhouse JP, Rosenthal MB. The economic impacts of the tobacco settlement. *J Policy Anal Manag.* 2002;21(1):1-19.

[2] Chaloupka FJ, Yurekli A, Fong GT. Tobacco taxes as a tobacco control strategy. *Tob control.* 2012;21(2):172-180.

[3] Levy DT, Tam J, Kuo C, Fong GT, Chaloupka F. Research Full Report: The Impact of Implementing Tobacco Control Policies: The 2017 Tobacco Control Policy Scorecard. *J Public Health Man.* 2018;24(5):448.

[4] Ross H, Al-Sadat NA. Demand analysis of tobacco consumption in Malaysia. *Nicotine Tob Res.* 2007;9(11):1163-1169.

[5] van Walbeek C. The economics of tobacco control in South Africa. 2005

[6] Boshoff WH. Cigarette Demand in South Africa over 1996-2006: The role of price, income and health awareness. *SAJE.* 2008;76(1):118-131.

[7] Joossens L, Raw M. The Tobacco Control Scale: a new scale to measure country activity. *Tob. Control.* 2006;15(3):247-253.

[8] Joossens L, Raw M. The tobacco control scale 2010 in Europe. *Brussels: Assoc European Can Leag.* 2011;201(1).

[9] Jha P, Peto R. Global effects of smoking, of quitting, and of taxing tobacco. *New Engl J Med.* 2014;370(1):60-68.

[10] Chelwa G, van Walbeek C, Blecher E. Evaluating South Africa's tobacco control policy using a synthetic control method. *Tob Control.* 2017;26(5):509-517.

[11] Linegar DJ, van Walbeek C. The effect of excise tax increases on cigarette prices in South Africa. *Tob Control.* 2018;27(1):65-71.

[12] Mukong AK, Tingum EN. The demand for cigarettes: New evidence from South Africa. *Dev So Afr.* 2019:1-15

[13] Shisana O. *The South African National Health and Nutrition Examination Survey: SANHANES-1.* HSRC press; 2013.

[14] Abedian I, Dorrington R. An evaluation of a recent attempt to assess the social benefits of cigarette smoking. *J stud E Econom.* 1994;18(1):59-72.

[15] Reekie WD. Consumers' surplus and the demand for cigarettes. *Manage Decision.* 1994;15(3):223-234.

[16] Van der Merwe R, Annett N. Chapter 4: The effects of taxation on consumption in South Africa. *ETCP SA.* 1998.

[17] Van Walbeek C. Impact of the recent tobacco excise tax increases on the future government revenue potential in South Africa. *ETCP SA.* 2000.

[18] Van Walbeek C. Recent trends in smoking prevalence in South Africa-some evidence from AMPS data. *SAMJ.* 2002;92(6):468-472.

[19] Walbeek CP. Excise Taxes on Tobacco: How Much Scope does the Government Have? *SAJE.* 1996;64(1):12-23.

[20] Fujii ET. The demand for cigarettes: further empirical evidence and its implications for public policy. *Appl Econ.* 1980;12(4):479-489.

[21] Nikolaou A, Velentzas K. Estimating the demand for cigarettes in Greece: an error correction model. *Agr Econ Rev.* 2001;2(1):22-29.

[22] Republic of South Africa. Budget Review. *http://wwwtreasurygovza/ documents/national%20budget/Budget%20Review%201996pdf.* 1996((accessed Oct 2018)).

[23] Republic of South Africa. Budget speech by the Minister of Finance. *http://wwwtreasurygovza/documents/national%20budget/2004/speech/Speechpdf* 2004((accessed Oct 2018)).

[24] World Health Organization. The World health report: 2003: shaping the future. 2003.

[25] van Walbeek C. The economics of tobacco control (Part 2): evidence from the ITC Project. In: BMJ Publishing Group Ltd; 2015.

[26] Dickey DA, Fuller WA. Distribution of the estimators for autoregressive time series with a unit root. *J Am Stat Assoc.* 1979;74(366a):427-431.

[27] Phillips PC, Perron P. Testing for a unit root in time series regression. *Biometrika.* 1988;75(2):335-346.

[28] Harris R. Using Cointegration in Economic Analysis. *Hemel Hempstead: Harvester Wheatsheaf.* 1995.

[29] Johansen S, Juselius K. Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford B Econ Stat.* 1990;52(2):169-210.

[30] Stock JH, Watson MW. Testing for common trends. *J Am Stat Assoc.* 1988;83(404):1097-1107.

[31] Toda HY, Phillips PC. Vector autoregressions and causality. *Econometrica.* 1993:1367-1393.

[32] Wilkins N, Yurekli A, Hu T-w. Economic analysis of tobacco demand. *Econ Tobacco Toolkit.* 2004;80576.

[33] Adda J, Cornaglia F. Taxes, cigarette consumption, and smoking intensity. *Am Econc Rev.* 2006;96(4):1013-1028.

Table 1: The Tobacco Control Policies and Index in South Africa

Year	The Tobacco Control Policies in South Africa from 1990	Scale	Cum. index
1980s	Smoking prevalence peaked in the 1980s	**0**	0
1998/99	Medical Research Council (MRC) publishes a paper showing that for every R1 of revenue, smoking costs government R5.	**0**	0
1990/91	The Minister of Health (MoH) is pushed into action and starts preparing the Tobacco Product Control (TPC) Bill	0	0
1992	Taxes make up 30% of tobacco product prices.	0	0
1993	The MoH introduces the TPC Act of 1993, mandating that health warnings be added to cigarette packs and advertising material, and prohibiting smoking on public transport.	3	3
1994	The Minister of Finance (MoF) announced an increase in excise tax burden on cigarettes to 50% of the retail price over the number of years	0	3
1997	To dissuade smokers, government raises taxes on tobacco products to 50% of cigarette the retail prices.	0	3
1999	An amendment to the Tobacco Products Control Act bans tobacco advertising, the sale of tobacco to minors (age limit raised from 16 to 18 years) and increases regulations around smoking in public places, including the workplace. The MoH is awarded the WHO Tobacco Free World Award.	11	14
2001	The law banning public smoking comes into effect. Smokers may only smoke outside and in cordoned off indoor areas. But restaurants can have smoking designated areas of up to 25% of the total area. Total ban on tobacco advertisement (enforced)	10	24
2004	Excise tax on tobacco products are raised to 52% of retail prices.	0	24
2005	South Africa ratifies the WHO's Framework Convention on Tobacco Control (FCTC), which gives governments a framework for quickly passing and implementing evidence-based tobacco control laws.	0	24
2008	An amendment to the TPC Act aligns the country's policies with FCTC guidelines by, for instance, raising the legal smoking age to 18 years, restricting tobacco sponsorship and promotion and mandating more extensive health warnings at points of sale.	2	26
2012	Draft regulations that would ban smoking in public places and certain outdoor public places, such as beaches and outdoor eating areas, are gazetted, but have not been passed into law.	0	26
2013	South Africa signs an international treaty to clamp down on the illegal trade in cigarettes.	0	26
2016	Minister of Health announces plans to introduce legislation that would: introduce plain packaging and pictorial health warnings; make indoor public places 100% smoke free; ban vending machines; restrict point of sale marketing; regulate ENDS/ENNDS as tobacco products	0	26

Source: Authors using The Tobacco Control Scale, 2010 (TCS), Joossens and Raw (2011).
NB: The index does not have a scale for restriction of the sale of tobacco to minors (age limit raised from 16 to 18 years as the policy is not included in Joossens and Raw (2011).

Table 2: Results of the estimated VECM

Variable	Short-run Dynamic		Long-run		2SLS	
	(1)	(2)	(3)	(4)	(5)	(6)
Error correction term	-0.152***	-0.259**	-	-		
	(0.058)	(.098)				
log of cigarette prices	-0.263**	-0.352**	-0.722***	-0.548***	-0.523***	-0.589***
	(0.133)	(0.165)	(0.107)	(0.097)	(0.101)	(0.084)
log of real per capita gdp	0.226*	0.283**	0.394***	0.487***	0.123***	0.052
	(0.203)	(0.217)	(0.077)	(0.052)	(0.044)	(0.040)
policy index	-	-0.007	-	- 0.016***	-0.011***	-0.006***
		(0.002)		(0.003)	(0.003)	(0.002)
changing market structure	-	0.039	-	-0.146***	-0.042	-0.062
		(0.028)		(0.051)	(0.046)	(0.042)
Constant	0.017***	0.026	9.094	1.087	3.626***	5.008***
	(0.010)	(0.013)	(0.160)	(1.029)	(0.799)	(0.696)
VECM diagnostic tests						
Autocorrelation: LM	8.392 (0.495)					
Normality: Jarque-Bera	1.874 (0.931)					
Stability: Eigenvalue	4 unit moduli					
Durbin (score) chi2(1)					*18.479***	*3.223**
Wu-Hausman F(1,50)					*24.625***	*3.05**

Note:

Numbers in parenthesis are standard error; ***, **, * denote significance at 1%, 5% and 10% respectively.

Columns (1) and (3) are the restricted models for the short and long run VECM respectively

Columns (2) and (4) are the unrestricted models

Column (5) is the 2SLS model using real excise taxes as an instrument

Column (6) is the 2SLS model using lag of prices as an instrument.

Figure 1: Real prices per pack and aggregate cigarette consumption, South Africa 1961-2017

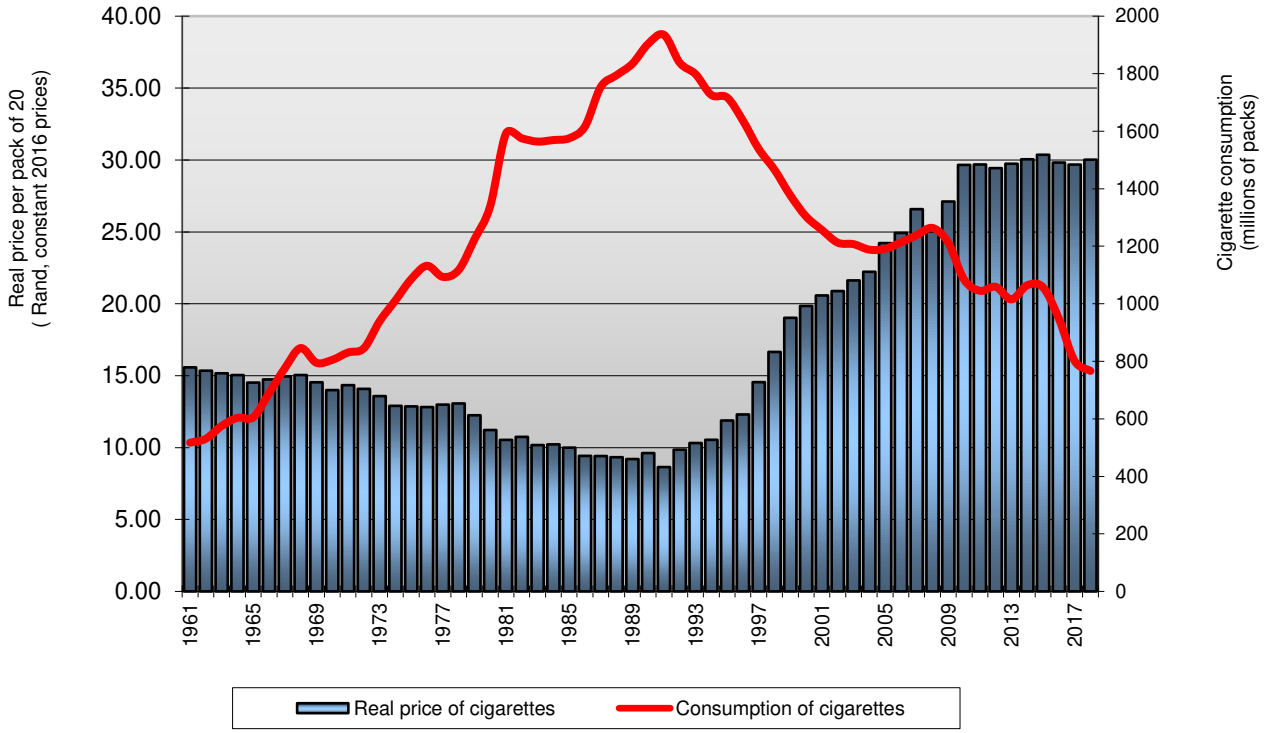
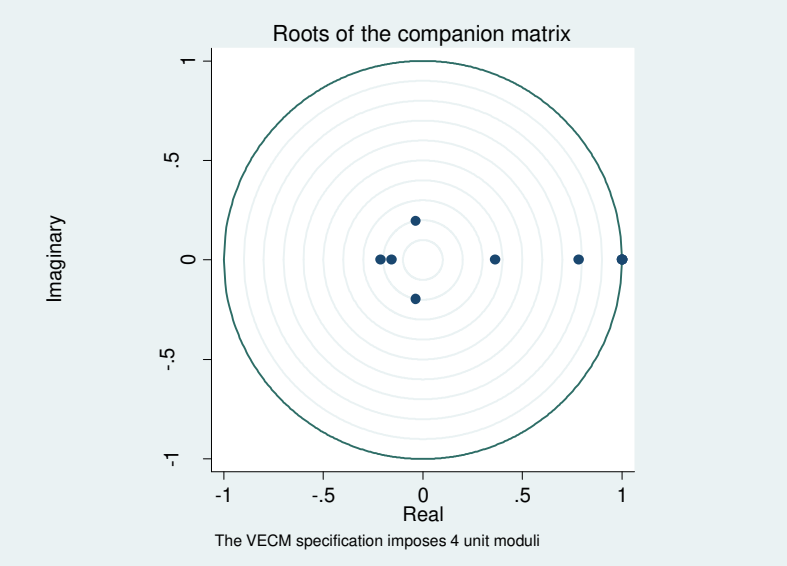
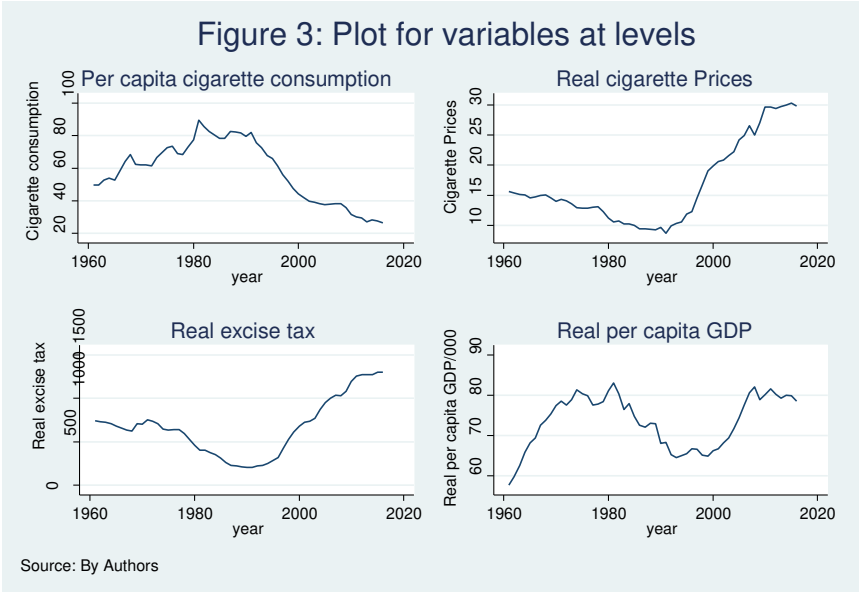


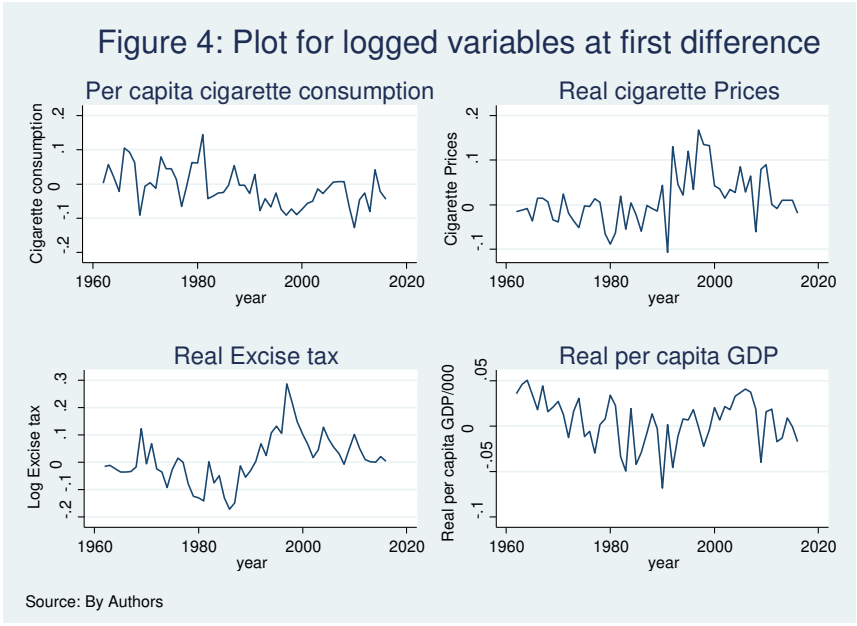
Figure 2: VECM stability test



Appendices

Appendix 1: Plot for variables at levels and first difference





Appendix 2: Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests

		Level		First difference	
Variable	**lags**	**ADF**	**PP**	**ADF**	**PP**
log(per capita consumption)	1	-1.698	-1.431	-4.474	-5.543
log(real prices)	1	-1.232	-1.115	-3.587	-5.522
log(real per capita gdp)	1	-3.127	-3.273	-4.175	-4.560

NB: 5% critical values are: -3.496 and -3.497 for the ADF test at level and first difference respectively; whereas the PP test critical values are -3.495 and -3.496 at level and first difference respectively.

Appendix 3: Optimal VAR Lag Selection criteria

lag	**LR**	**Df**	**p**	**FPE**	**AIC**	**HQIC**	**SBIC**
0				4.8e-06	-3.72732	-3.68417	-3.61475
1	416.27*	9	0.00	2.3e-09*	-11.3863*	-11.2137*	-10.936*
2	15.039	9	0.09	2.4e-09	-11.3294	-11.0273	-10.5414
3	7.2512	9	0.61	3.0e-09	-11.1227	-10.6911	-9.99696
4	13.705	9	0.13	3.3e-09	-11.0401	-10.479	-9.57665

Appendix 4: Johansen-Juselius Maximum Likelihood Test for Cointegration

		Trace Statistics		Maximum eigenvalue	
Null	**Eigenvalue**	**statistic**	**5% critical value**	**statistic**	**95% critical value**
r=0	N/A	55.1446	29.68	47.6385	20.97
r<1	0.57943	7.5061*	15.41	7.3605	14.07
r<2	0.12526	0.1456	3.76	0.1456	3.76

Appendix 5: First Stage Estimates of 2SLS

	Excise taxes	**Lagged prices**
log of real excise taxes	0.384***	-
	(0.0368)	
log of lagged prices	--	1.0257***
		(0.0674)
log of real per capita gdp	0.0224	0.0600*
	(0.0436)	(0.0339)
policy index	0.009***	.007*
	(0.0017)	(0.0018)
changing market structure	-0.0755*	-.0411
	(0.0429)	(.0325)
Constant	-0.1506	-0.874
	(0.7734)	(0.5944)
Number of obs	56	55
F(4, 51)	391.46	699.38
R-squared	0.9685	0.9824
Adj R-squared	0.9660	0.9810

Numbers in parenthesis are standard error; ***, **, * denote significance at 1%, 5% and 10% respectively.

Appendix 6: Regression results using specific dummies

	(1)	(2)	(3)
log of cigarette prices	*-0.447****	*-0.447****	*-0.566****
	(0.083)	*(0.083)*	*(0.076)*
log of real per capita gdp	*0.182****	*0.182****	*0.117****
	(0.044)	*(0.044)*	*(0.043)*
changing market structure	*-0.234****	*-0.234****	*-0.211****
	(0.045)	*(0.045)*	*(0.043)*
Legislation 1	*-0.224****	*-0.224****	*-0.174****
	(0.043)	*(0.043)*	*(0.041)*
Legislation 2	*-0.465****	*-0.465****	*-0.336****
	(0.089)	*(0.089)*	*(0.084)*
Legislation 3	*-0.486****	*-0.486****	*-0.322****
	(0.114)	*(0.114)*	*(0.108)*
Constant	*2.908****	*2.908****	*4.089****
	(0.760)	*(0.760)*	*(0.730)*
Observations	*56*	*56*	*55*
R-squared	*0.970*	*0.970*	*0.973*
Durbin (score) chi2(1)		*9.587 (p = 0.002)*	*0.016 (p = 0.898)*
Wu-Hausman F(1,48)		*9.916 (p = 0.003)*	*0.014 (p = 0.907)*

Numbers in parenthesis are standard error; ***, **, * denote significance at 1%, 5% and 10% respectively.

Note:

Columns (1) is the long run VECM results using specific dummies
Column (2) is the 2SLS model using real excise taxes as an instrument
Column (3) is the 2SLS model using lag of prices as an instrument

Specific dummies have been used for the existing tobacco legislation in South Africa.
Tobacco Products Control Act, Act no. 83 of 1993
Was amended by:
Tobacco Products Control Amendment Act, no12 of 1999;
Tobacco Products Control Amendment Act, no 23 of 2007 &
Tobacco Products Control Amendment Act, no 63 of 2008.

Appendix 6: Tobacco Control Scale by Joossens and Raw (2011)

No	Tobacco Control Policy	Scale
1	**Price of cigarettes and other tobacco products**	**30**
2	**Smoke free work and other public places**	**22**
	Workplaces excluding cafes and restaurants - only one of	10
	Complete ban without exceptions (no smoking rooms); enforced	10
	Complete ban, but with closed, ventilated, designated smoking rooms under very strict rules; enforced	8
	Complete ban, but with ventilated, designated smoking rooms (not areas or places); enforced	6
	Meaningful restrictions; enforced (75% of the workplace are smoke free)	4
	Legislation, but not enforced	2
	Cafes and restaurants - one only of	8
	Complete ban; enforced	8
	Complete ban, but with closed, ventilated, designated smoking rooms (not areas or places); enforced	6
	Meaningful restrictions; enforced (50% of bars and restaurants are smoke free)	4
	Legislation, but not enforced	2
	Public transport and other public places - additive	4
	Complete ban in train without exceptions	1
	Complete ban in other public transport without exceptions	1
	Complete ban in educational, health, government and cultural places without exceptions OR	2
	Ban in educational, health, government and cultural places, but with designated smoking areas or rooms	1
3	**Spending on public information campaigns**	**15**
4	**Comprehensive bans on advertising and promotion**	**13**
	Points for each type of ban included - additive	1
	Complete ban on tobacco advertising on television and radio	2
	Complete ban on outdoor advertising (e.g posters)	2
	Complete ban on advertising in print media (e.g newspapers and magazines)	1.5
	Complete ban on indirect advertising (e.g cigarette branded cloths, watches …)	1
	Ban on display of tobacco products at the point of sales	2
	Ban on point of sale advertising	1
	Ban on cinema advertising	1
	Ban on sponsorship	1
	Ban on internet advertising	0.5
5	**Large direct health warning labels**	**10**
	Plain packaging (the removal of trademarks, logos, colours and graphics, except for the government health warning and for the brand name, presented in a standardized typeface) in combination with pictorial health warnings in the front and the back of the tobacco product packages	4
	Size of warning - one only of	3
	50% or less of packet	1
	51 - 79% of packet	2
	80% or more of packet	3
	Pictorial health warnings - additive	3
	Pictorial health warnings on cigarette packs	2
	Pictorial health warning on hand rolling tobacco	1
6	**Treatment to help dependent smokers stop**	**10**
	Recording of smoking status in medical notes	1
	Legal or financial incentive or record to record smoking status in all medical notes or patient files	1
	Brief advice in primary care	1
	Family doctors reimbursed for providing brief advice	1

	Quit line	2
	National quit line or quit line in all major regions of country	1
	Quit line counsellors answering at least 30 hours a week (not recorded)	1
	Network of smoking cessation support and its reimbursement - one only of	**4**
	Cessation support network covering whole country, free	4
	Cessation support network but only in selected areas, eg major cities; free	3
	Cessation support network covering whole country, partially or not free	3
	Cessation support network but only in selected areas, eg major cities; partially or not free	2
	Reimbursement of medications - one only of	**2**
	Medications totally reimbursed or free to users OR	2
	Medications partially reimbursed	1

Source: Joossens and Raw (2011)